A Left Ventricular Assist Device (LVAD) is a mechanical pump that is utilized as a bridge to transplantation for patients with a Heart Failure (HF) condition. More recently, LVADs have been also used as destination therapy and have provided an increase in the quality of life. However, despite improvements in VAD design and anticoagulation treatment, there remains a significant problem with VAD therapy, namely drive line infection and thromboembolic events leading to stroke. This thesis focuses on a surgical maneuver to address the second of these issues, guided by previous steady flow hemodynamic studies have shown the potential of tailoring the VAD outflow graft (VAD-OG) implantation can provided up to 50% reduction in embolization rates. In the current study, multi-scale pulsatile hemodynamics of the VAD bed is modeled and integrated in a fully automated multi-objective shape optimization scheme in which the VAD-OG anastomosis along the Ascending Aorta (AA) is optimized to minimize the objective function which include thromboembolic events to the cerebral vessels and Wall Shear Stress (WSS). The model is driven by a time dependent pressure and flow boundary conditions located at the boundaries of the 3D domain through a 50 degree of freedom 0D lumped parameter model (LPM). The model includes a time dependent multi-scale Computational Fluid Dynamics (CFD) analysis of a patient specific geometry. Blood rheology is modeled as using the non-Newtonian Carreua-Yasuda model, while the hemodynamics are that of a laminar and constant density fluid. The hemodynamics are resolved using the commercial CFD solver StarCCM+ while a Lagrangian particle tracking scheme is used to track constant density particles modeling thromobi released from the cannula and aortic root to determine embolization rated of thrombi. The results show that cannula anastomosis orientation plays a large role when minimizing the objective function. The scheme determined the optimal location of the cannula is located at 5.5 cm from the aortic root, cannula angle at 90 degrees and coronal angle at 8 degrees along the AA with a peak surface average WSS of 55.97 dynes/cm² and stroke percentile of 12.51%. A Pareto front was generated showing the range of 9.7% to 44.08% for stroke and WSS of 55.97 to 81.47 dynes/cm² ranged over 22 implantation configurations for the specific case studied. These results will further assist in the treatment planning for clinicians when implementing a LVAD.